Quantitative Analysis Of The Impact Of Socio-Economic Status (SES) And Dementia Status On Cognitive Function And Brain Volume

Introduction

Dementia stands as a critical challenge impacting millions globally, not only affecting individuals but also straining families and healthcare infrastructures. It is a painful, desperate, and heartbreaking process once someone starts to get affected by this disease. Within this context, our study investigates how socio-economic factors intersect with dementia to influence cognitive decline and brain volume changes over time. This way, we can shed more light and bring more insights into the causing factors for future studies.

We are using INF2178_A4_data as the data frame for this study.

The research question is: *How does socio-economic status (SES) affect the progression of cognitive function (as measured by MMSE scores) and brain volume (as measured by nWBV) over time?*

Data Cleaning

We have found several values that need to be added, especially regarding the MMSE and SES research targets. However, considering our large data sizes, we would employ a model—using each column's median to fill such missing values for the coming analysis.
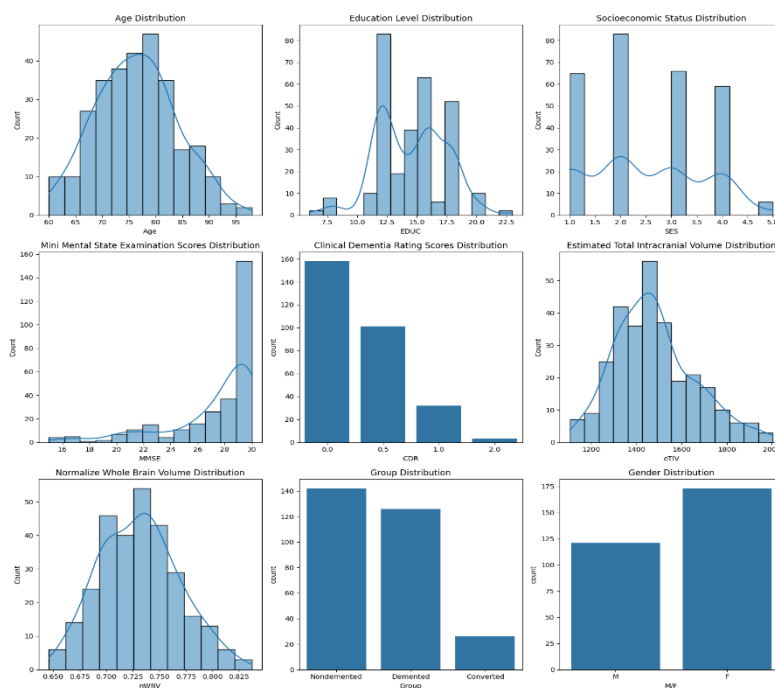
EDA

Figure 1 Exploratory Data Analysis

We have conducted EDA on the dataset before our test: The dementia study dataset reveals a diverse sample of middle-aged to elderly individuals, as evidenced by the normally distributed age and estimated total intracranial volume (eTIV), and a variation in education levels around 12-17 years of educations. Socioeconomic status (SES) shows most of them are lying within the middle-lower class of the status. Cognitive function, assessed by the Mini-Mental State Examination (MMSE), predominantly showcases higher scores, with a distribution skewed

towards minimal cognitive impairment. In contrast, the Clinical Dementia Rating (CDR) scores suggest most participants do not have dementia, still highlighting a spectrum of severity is shown. The normalized whole brain volume (nWBV) follows a normal distribution. The group distribution is skewed with more nondemented individuals, and a more significant number of female participants is noted, aligning with some research that could be done to investigate gender disparities in dementia prevalence further.

Mixed Effects ANOVA
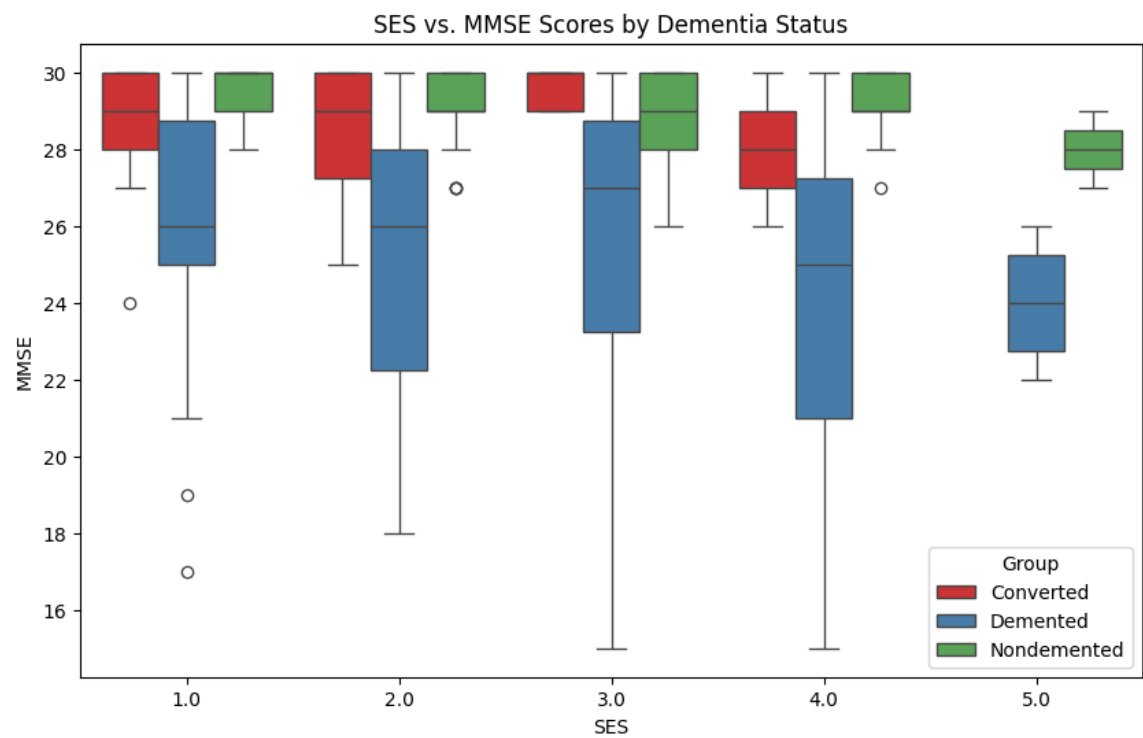
MMSE vs SES (Figure 2)

Figure 2 SES vs MMSE Data Visualization

The mixed-effects ANOVA for cognitive function, as measured by MMSE scores, does demonstrate a significant effect of time (Visit) on cognitive function (F=8.015, p=0.005), indicating that cognitive function changes significantly over visits. However, socioeconomic status (SES) did not show a statistically significant main effect on MMSE scores (F=1.599, p=0.178.

```
     Source          SS  DF1  DF2        MS         F     p-unc       np2  \
0       SES  131.240601    4  139  32.810150  1.599323  0.177896  0.043999
1     Visit   20.586806    1  139  20.586806  8.015490  0.005327  0.054521
2  Interaction  19.908705  4  139   4.977176  1.937868  0.107512  0.052820

     eps
0    NaN
1    1.0
2    NaN
```

Figure 3 Mixed Anova MMSE vs SES vs Visits

Post hoc tests revealed significant differences in MMSE scores between SES groups 1 and 4 (p=0.008, corrected p=0.079), indicating a meaningful difference in cognitive function between these SES groups at a specific time point. Other comparisons between SES groups did not reach statistical significance after correction for multiple comparisons, highlighting a nuanced relationship between SES and cognitive function.
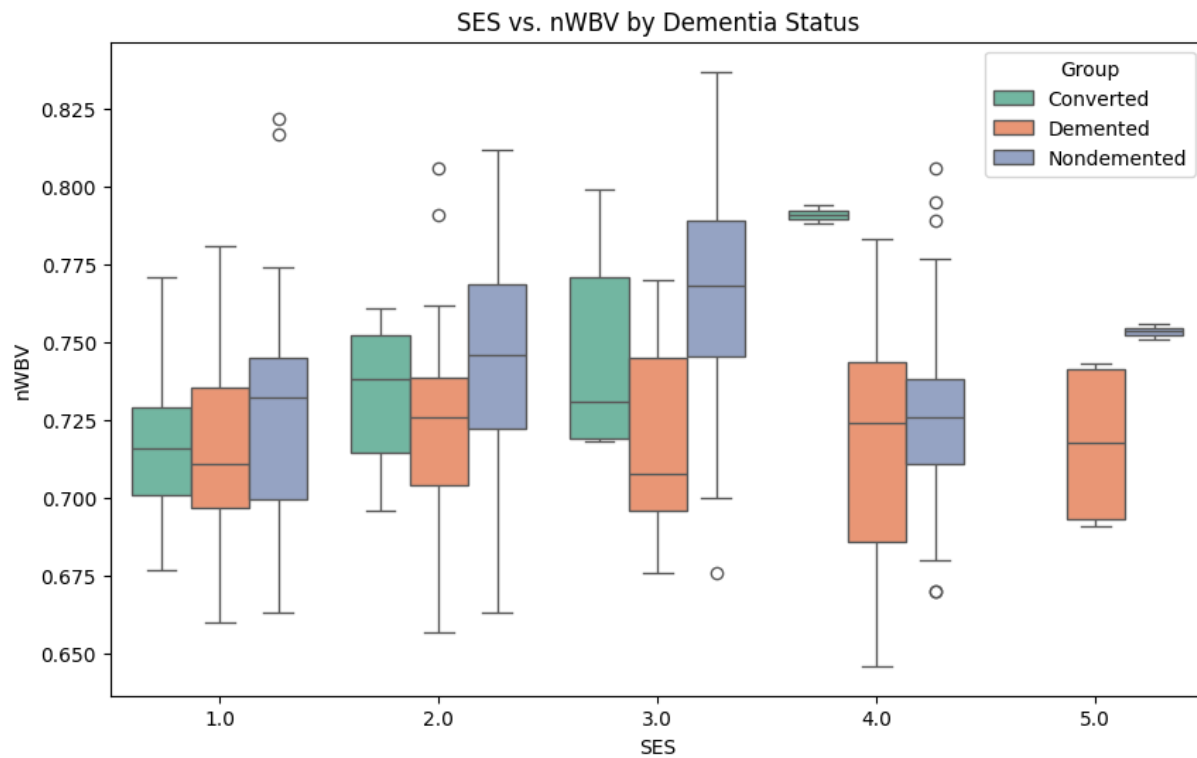
nWBV vs SES (Figure 3)

Figure 4 SES vs nWBV Data Visualization

For brain volume (nWBV), the mixed-effects ANOVA indicated a highly significant effect of time (Visit) on nWBV (F=92.664, p<0.0001), which shows the impact of time on brain volume reduction. However, the main effect of SES and the interaction between SES and Visit were not statistically significant (SES: F=1.493, p=0.208; Interaction: F=0.660, p=0.621), suggesting that SES does not significantly modulate brain volume changes over time within this dataset.

```
       Source         SS  DF1  DF2        MS          F        p-unc  \
0         SES   0.015940    4  139  0.003985   1.492978  2.075962e-01
1       Visit   0.006508    1  139  0.006508  92.664084  4.036161e-17
2  Interaction  0.000185    4  139  0.000046   0.660251  6.206442e-01

        np2  eps
0  0.041194  NaN
1  0.399993  1.0
2  0.018646  NaN
```

Figure 5 Mixed Anova nWBV vs SES vs. Visits

Post hoc tests for nWBV showed a significant difference between SES groups 1 and 3 (p=0.007, corrected p=0.065), indicating a statistically significant difference in brain volume between these SES groups at certain visits. However, the lack of significant interaction suggests that the trajectory of brain volume change over time does not vary significantly by SES.

The findings reveal that while cognitive function and brain volume may be significantly related to the visits, which are longitude factors involved in this study, these factors are not significantly related or affected by the socio-economic status over the periods.

We can see the dominant relationship between cognitive function and brain volume in terms of the variable of time, which means that time is a significant factor. However, regardless of how one might think about the importance of wealth and social status and how it may help when sick, such characteristics will not help us win the battle against dementia, at least in this study. When we are faced with such irreversible diseases like dementia, common advantages, social levels, will no longer be there to provide support; Simply remembering what you have had will be a challenge. This result prompts me to think more about what is essential in life.